E-24-60R
#2

Final Report US Dept of Defense ARO 240660R

Multiscale Approach to Functional Data Analysis with Applications in Monitoring, PI Brani Vidakovic

The ***Project Multiscale Approach to Functional Data Analysis with Applications in Monitoring*** have ended in June 06 after 2 years of funded research and a semester of no-cost extension.

The aim of this project was to develop and apply wavelet-based methodology to the statistical observations that arise in various monitoring situations (defense monitoring, radar and mechanical system monitoring, environmental monitoring, etc.). Given the observations that are coming from different treatments, the methodology developed in the course of funded research is capable of analyzing their convolved complex structures and separating them into components corresponding to a global average and to functional effects linked to particular treatments. At the same time, the dimension is reduced and estimators are regularized. The typical data can be thought as sampled values of continuous single- or multivariate functions.

The PI took a multiresolution point of view to processing such functional data. The emerging wavelet-based methodologies are shown to be suitable of successfully dealing with limitations of standardly used procedures. Necessary regularization and dimension reduction are achieved by wavelet shrinkage, while the intrinsic problem of autocorrelation is greatly reduced when the analysis is carried out in the wavelet domain. The interplay between engineering and statistical modeling and inference, a crucial part of this research, is enhanced by Bayesian paradigm. Such Bayesianly induced incorporation of information is of critical importance in situations when the phenomena are not repeatable, or when the sampling is overly expensive.

In the years 2004 and 2005 the accomplishments supported by the award 240660R supported the PI and graduate student Bin Shi in research outlined in the proposal. As a result several papers are published or accepted for publication. A few papers are under revision or are submitted. They all acknowledge either partial (in the case of the multiple authorship) or the full support by the NSA grant 240660R.

Below listed are the supported publications with a brief description and publication status.

Two book chapters describing the research methodology outlined in the grant proposal and one paper are published or in press:

1. Vidakovic, B. (2004). Transforms in Statistics, In: *Handbook of Computational Statistics Concepts and Methods*, Chapter II.7. Editors Gentle, J., Hardle, W., and Mori, Y., Springer-Verlag, Heidelberg, ISBN 3-540-40464-3, pp. 199--236.

2. Ruggeri, F. and Vidakovic, B. (2005). Bayesian Modeling in the Wavelet Domain, Chapter in *Handbook of Statistics* Vol. 25, on Bayesian Statistics (C.R. Rao and Dipak Dey), 315–338.

and

3. Shi, B., Vidakovic, B., Katul, G., and Albertson, J. (2005). Assessing the Effects of Atmospheric Stability on the Inertial Subrange of Surface Layer Turbulence using Local and Global Multiscale Approaches, in press in *Physics of Fluids*, 17, 0545104, 1--12.

This paper is describing
Bayesian dimension reduction and functional wavelet ANOVA using the data collected under various stability conditions.

4. Katul, G., Ruggeri, F.,} and {\sc Vidakovic, B. (2006). BAMS Filtering and Applications to Denoising Ozone Concentration Measurements,
Journal of Statistical Planning and Inference, 136, 2395–2405.

5. Pensky, M., Vidakovic, De Canditiis, D. (2006).
Bayesian Decision Theoretic Scale-Adaptive Estimation of Spectral Density. Technical Report, ISyE, Georgia Institute of Technology. To appear in *Statistica Sinica*.

6. Moloney, K., Shi, B., Leonard, K. V., Jacko, J., Vidakovic, B.,
and Sainfort, F. (2006). Using multifractality for user classification: Dynamic pupil behavior affected by ocular pathology,
To Appear in Special Issue of *ACM Transactions on Human-Computer Interaction (TOCHI)*

This grant was a two year award and the principal investigator is confident that the research resulted from such funding was successfully disseminated.